Lisbon School of Economics & Management
Universidade de Lisboa

MASTER

ACTUARIAL SCIENCE

MASTER'S FINAL WORK

INTERNSHIP REPORT

OPERATIONAL RISK IN THE ACTUARIAL VALUATIONS OF DEFINED BENEFIT PENSION SCHEMES

ANA LUÍSA PAQUETE MARQUES

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SUPERVISION:

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Abstract

Operational risk has always been a concern throughout history, especially since the 2008 financial crisis. Organisations, now more than ever, focus on excellence and regulation. Through the recognition of operational risk as an intrinsic part of organisations and an effective risk management strategy, operational risk can be leveraged as an advantage for organisations.

UK law requires that, every three years, defined benefit pension schemes should be subject to an actuarial valuation. The goal of this is to provide a clear view of the scheme's liability, which allows for a proper asset-liability management. As new technologies are developed, new challenges arise in terms of ensuring the maximum quality of results provided by actuarial valuations.

In the context of a five-month curricular internship at Willis Towers Watson's Lisbon subsidiary, which led to a deep exploration of actuarial valuations of defined benefit pension funds, I was given the project to do a deep study of the specific mechanisms in place to manage the operational risk and to guarantee the accuracy of the results produced.

To present my findings, I simulated two types of errors, into a sample client: input errors (changes in the client's data) and setup errors (changes in the information embedded into the internal software, used for the calculations). After simulating the errors, I saw how they could be identified using the internal mechanisms designed to prevent them. The overall conclusion is that the operational risk is well managed in the organisation, which contributes to the quality of the services provided.

KEYWORDS: Pension fund, Operational risk, Actuarial valuations

Resumo

O risco operacional tem sido sempre uma preocupação ao longo da história, especialmente depois da crise financeira de 2008. As organizações, agora mais do que nunca, focam-se em excelência e regulação. Através do reconhecimento do risco operacional como uma parte intrínseca das organizações e de uma estratégia de gestão de risco eficaz, a correta gestão do risco operacional pode ser aproveitada como uma vantagem para as organizações.

A lei do Reino Unido exige que, a cada três anos, os planos de pensões de benefício definido devem ser sujeitos a uma avaliação atuarial. O objetivo é providenciar uma visão clara dos passivos do fundo em questão, o que permite uma adequada gestão de ativos-passivos. À medida que se desenvolvem novas tecnologias, aparecem novos desafios em termos de garantir a máxima qualidade dos resultados providenciados pelas avaliações atuariais.

No contexto de um estágio curricular de cinco meses na subsidiária lisboeta da Willis Towers Watson, que levou a uma exploração profunda de avaliações atuariais de planos de pensões de benefício definido, foi-me proposto que investigasse os mecanismos específicos em vigor para garantir a precisão dos resultados produzidos.

Para ilustrar todo o processo, simulei dois tipos de erros, num cliente amostra: erros de input (mudanças nos dados do cliente) e erros de setup (mudanças na informação colocada nos softwares internos, usados para os cálculos). Uma vez a simulação feita, foi possível identificar os mecanismos internos desenhados para os prevenir. No geral, concluí que que o risco operacional é bem gerido na organização, contribuindo para a qualidade dos serviços providenciados.

PALAVRAS-CHAVE: Fundo de pensões, Risco Operacional, Avaliações atuariais

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Acronyms and abbreviations

AoS	Analysis of Surplus
CARE	Career Average Revalued Earnings
CBT	Current Benefits Template
CO	Consulting Office
CPI	Consumer Price Index
DCT	Data Checking Template
DOB	Date of Birth
DOL	Date of Leaving
GMP	Guaranteed Minimum Pension
GPA	GMP Payment Age
LSC	Lisbon Service Center
LVD	Last Valuation Date
NRA	Normal Retirement Age
RPI	Retail Price Index
RRF	Run Request Form
TVD	This Valuation Date
WTW	Willis Towers Watson

1. Introduction

This report was produced in the context of a curricular internship as an actuarial analyst at Willis Towers Watson (WTW), more specifically at the Lisbon Service Center (LSC). The LSC is a division of WTW that performs actuarial valuations of UK-based defined benefit pension schemes, in its UK Valuation team, collaborating with the Consulting Office (CO) team (the team of WTW's UK subsidiary that deals directly with customers requesting the valuations). The internship consisted in extensive training on the company's values, the standard procedures, pension funds, and the software used internally for data treatment and calculations. This was a good overview of the work processes I would be dealing with. After the training, and for the rest of the internship's duration, I was able to see in practice how the actuarial valuations process worked and was able to perform its different workstages, which I will later develop on.

Throughout my training process, I was interested specifically on the several automated processes that were in place: whether it was macros that were implemented to fill templates more easily or the existence of the internal software itself, which perform the calculations, instead of people doing them by hand. I noticed that these automated processes were always verified, which was an efficient way of identifying any possible mistakes in the previous steps. This drove the thesis' theme of connecting operational risk to defined benefit pension schemes. With this report I want to take a better look at how errors could affect results and the mechanisms implemented at the LSC to prevent mistakes, in the framework of managing the operational risk to assure the quality of the service.

In terms of information collection, besides extensive research, I looked into my own experience in performing actuarial valuations, to be able to identify the mechanisms that were checking the results of the work I was producing, as well as any errors I made that impacted the results.

In Chapter 2 I will explain some basic pension funds terms that are necessary to have a better understanding of the report, such as the concept of a pension fund, all the different statuses that its members can belong to and some rules that regulate the UK occupational pension schemes. Chapter 2 will also include an introduction to the actuarial valuations process.

Throughout Chapter 3, I will develop on the topic of operational risk: how its presence affects organisations, how it can lead to losses and the ways to manage it. I will connect the topic of operational risk to defined benefit pension schemes and then follow up on that link in Chapter 4, where I will explore the LSC's mechanisms of operational risk management.

Chapter 5 will bring a practical outlook on the operational risk management throughout the actuarial valuations, performed on defined benefit pension schemes. With the simulation of both input and setup errors (errors in the data received, and in the information embedded into the software, respectively), I aim to explore the possible impact of the errors (in case there were no safeguard mechanisms in place) and how they can be easily identified. Chapter 6 concludes.

2. Basic pension funds terms

A pension scheme is a saving plan for the long run, the idea being that saving up during a person's active years will allow for income during retirement. (Money Helper 2021a)

Receiving pensions is what allows people who retire in their later stages of life to maintain dignity and a certain standard of living. Pensions are, therefore, an integral part of all people's lives.

The UK pension system consists of three tiers: the State Pension, Additional State Pension and Private Pension. The first two tiers are responsibility of the State, while the funding of the third is private and composed of Occupational Schemes, Personal Schemes as well as Multi-Employer Schemes. (Pensions Policy Institute 2020)

Occupational or Workplace Pension Schemes provide benefits related to employment and are offered and sponsored by employers as a way of attracting and retaining talent. Contributions are made by the employer and sometimes there can be the addition of employee contributions. Some extra benefits besides the pension for the member at retirement can be included, for example, the payment of pension to the spouse or to the children in case of death of the member, a pension in case of disease or accident or the possibility of commutation (taking a cash lump sum at retirement corresponding to a portion of the benefits to which the scheme member is entitled).

2.1. Types of occupational schemes

Occupational Schemes usually follow one of two possible routes: defined benefit or defined contribution. They differ from each other mainly in terms of legislation that applies to each and who bears the risk, which are definitely important issues.

1. Defined contribution

In these schemes the contributions made to the pension plan are defined in advance, usually as a percentage of salary earned. The benefits that the member is entitled to at retirement depend on the investment returns of the amount gathered in the fund until that point.

2. Defined benefit

When a pension scheme is of the defined benefit type, the amount to be received at retirement is known in advance. This means that, at retirement, it is the employer that must meet the obligation of covering the benefits its employee was promised. To ensure that the assets in the

pension fund (the pension fund's economic resources that can generate future economic benefit (Barone 2021)) are enough to cover the liabilities (in simplistic terms, liabilities are an obligation by the liability's owner which owes something, usually a certain amount of money (Hayes 2021)), the pension plan must go through an actuarial valuation, a concept that will be defined later.

The pension income can be calculated in the following way, see for instance (Money Helper 2021b).

$$Pension = Years\ in\ the\ scheme * Accrual\ rate * Pensionable\ earnings \quad (1)$$

The pensionable earnings are usually determined using either the Final Salary or Career Average Revalued Earnings (CARE) methods. With the Final Salary approach we simply calculate the member's benefits based on their last salary, but with the CARE approach we use an average of a certain number of past salaries, starting by the final one. Since the member's final salary (or final salaries) are not known in advance: assumptions on salary escalation must be made so that the liability that each member represents can be considered.

One very important thing to consider is that the pension the member is often entitled to is subject to increases, mainly to keep up with inflation. These increases can be applied before retirement as well as after. The increases are usually based in one of two inflation indicators: RPI (Retail Price Index) or CPI (Consumer Price Index). The application of caps and floors can also be done to ensure that the inflation indicators do not stray from a certain upper or lower limit, respectively: if the indicator to be considered is lower than the floor, then the increase applied is the floor; if it is larger than the cap, then the increase will be equal to the cap, otherwise the increase will be equal to the indicator. The notation that takes into account the floor and cap is usually the following: CPI(RPI)_Floor_Cap%. For example: assuming increases are based in CPI with a floor of 0% and a cap of 3%, this is commonly referred to as CPI_0_3%. If the CPI of a certain point in time is 3.5%, the increase applied will be 3%. If, however, it is -0.5%, the increase applied will be 0%.

Defined benefit pension schemes can offer advantages and disadvantages on the side of the employer and employee when compared with defined contribution pension schemes. On the side of the employee, the defined benefit pension scheme has the advantage of the member not having to bear risk and uncertainty as this is on the side of the employer. On the other hand, a defined contribution pension scheme can be more advantageous to the employee as it gives its members more control on the choice of investments made.

From now on, only defined benefit pension funds will be considered since they are the subject of the actuarial valuations I worked on during my internship.

2.2. Composition of benefits

Benefits offered by a pension scheme are usually split into two categories: Guaranteed Minimum Pension (GMP) and non-GMP (usually referred to as excess). Each receive different treatment in terms of increases.

2.2.1. Guaranteed Minimum Pension (GMP)

In the period between 6th of April 1978 and 31st of March 2016, the pension provided by the state consisted of two tiers: a Basic State Pension and the State Second Pension (also known as State Earnings Related Pension Scheme). From 1978 the occupational schemes could opt to "contract out" of the Second State Pension, meaning that members would not be entitled to this, if they preferred to instead benefit from a cutback on National Insurance Contributions. (WTW Training Materials 2021a).

In order to ensure that these members who contracted out wouldn't be harmed, the GMP was created, as being the minimum that a scheme must pay its contracted out members, once they reach GMP Payment Age, GPA (65 for males and 60 for females). This was the system from 6th of April of 1978 to 5th of April 1997. After 1997 GMP was abolished.

Given this, members that accrued pension while the GMP policy was in force have two main types of pension: GMP and non GMP (commonly known as excess). Each receive different treatment in terms of the age from which they are paid unreduced or the revaluation they are subject to. Within GMP there is also a significant split between two categories: GMP accrued before 1988 and after (Post and Pre 88 GMP).

Before 1988, the State was in charge of providing the increases, so the scheme does not need to cover any increases on Pre 88 GMP. In the following years the entity responsible for the increases was the pension scheme, in this case they correspond to CPI_0_3%.

In case of the member leaving service before the GPA, the law requires that there must be a revaluation of the GMP up to GPA using one of the three following methods:

1. Fixed Rate revaluation: GMP is increased at a fixed rate between the DOL (Date of Leaving employment) of the member and their date of attaining GPA;

2. Section 148 revaluation: the method is the same as Fixed Rate revaluation but the actual increases applied are based on Section 148 orders. Section 148 orders are rates of increase determined in line with the National Average Earnings index (Mainwood 2014);
3. Limited Rate revaluation: this method states that GMP is increased by the minimum between the Section 148 orders and 5% per annum between the DOL of the member and their date of attaining GPA.

The choice between these three methods is specified within a pension scheme's rules.

2.2.2. Excess pension

Excess pension is subject to rules of revaluation that are different than those from GMP. The revaluation received depends on the DOL of the member:

- Member that left before 01/01/1986: the pension receives no revaluation;
- Member that left between 01/01/1986 and 31/12/1990: any pension accrued on or before 31/12/1984 receives no revaluation, pension accrued on or after 01/01/1985 receives revaluation compounded for each complete year from the DOL to the normal retirement date set by the scheme in line with either CPI or RPI, subject to a cap of 5%.
- Member that left after 01/01/1991: the excess pension receives revaluation compounded for each complete year from the DOL to the normal retirement date set by the scheme in line with either CPI or RPI, subject to a cap of 5% for service before 06/04/2009 and a cap of 2.5% for service after 06/04/2009.

2.3. Types of Scheme Members

In terms of their status within the scheme and subsequent benefits they are entitled to, we can split scheme members into four main categories: actives, deferreds, retirees and dependants.

Actives are still having contributions being made in their name towards the pension scheme at the time of analysis. This means that, in order to account for the liability that an active represents in a defined benefit pension scheme, we need to look at their salaries and take assumptions on any future salary changes that will impact the pension they will receive at retirement.

An active is also a member that can pass to almost all other states, as they can leave their employment and become deferreds or leave the scheme through death, in which case there is the possibility of them having dependants who will then be entitled to pension payments.

Deferreds are members that stopped having contributions made in their name towards the pension scheme. This usually happens when the member chooses to leave the company they are employed at before retirement. When analysing deferreds, the amounts that are used for calculations are usually fixed at the date that the member left. A deferred can either become a retiree or leave the scheme through death. In the case of death the deferred can leave dependants who will receive a pension.

Retirees are members of the scheme that have already retired. A retiree cannot move to any other state within the scheme, the only way out of the state being the member's death. Retirees only receive what we call in-payment increases as the member is already receiving the pension. A split can often be made between retirees who have reached GPA and those who have not, as a scheme's defined retirement age can be different from GPA. This division can be useful in identifying if an unexpected increase in the Pre 97 Excess, combined with an unexpected increase in GMP is due to certain members reaching GPA in the period between two valuations or if it is not related to that. For example, if a pension scheme's normal retirement age is 62, then a male member who retires between 62 and his GPA (which is 65 for males) should start receiving a pension at retirement, but would not be entitled to GMP yet. This topic, and the proper way to handle this type of situation, will be explored in later chapters, where GMP savings will be discussed.

Dependants usually enter the scheme through association with another member. They can be a member's spouse or child that became entitled to a certain pension amount after their death.

A vital concept to define, when talking about defined benefit pension schemes, is Normal Retirement Age (NRA). NRA is an age set by each pension scheme from which a member can retire with full benefits. (The Pensions Authority 2021). The unreduced payment age is the age from which a member can retire with full benefits, taking into account the number of years of service, and no reduction for early payment.

2.4. Actuarial valuations: LSC's process

Actuarial valuations of pension schemes are instrumental to their correct management. Its purpose is to analyse and review the scheme's liabilities, and weigh them against the available assets. By determining whether the scheme is able to cover its liabilities (or not), the money that needs to be paid into the fund can be determined.

Actuarial valuations must be performed by actuaries as they require their specific skills when it comes to establishing economic and demographic assumptions for the future, as well as their

ability to perform complex calculations, as previously seen. According to UK law the actuarial valuations of pension schemes must be performed once every three years (TRAF 2021).

Two important concepts to define in actuarial valuations are:

1. This Valuation Date (TVD): the effective date at which the liability is calculated;
2. Last Valuation Date (LVD): the date at which the last valuation was performed.

The valuation process in the LSC is split into eight different workstages (WTW Training Materials 2021c):

1. Preparation workstage: Encompasses the agreement of scope of work, deadlines and the preparation of three very important documents: the RRF (Run Request Form, a document that states the different runs of calculations that are requested and the different assumptions that should be used for each), Consolidated Planner (the document where the timetables for each workstage are stated along with some specific requests for the valuation) and the CBT (Current Benefits Template, where the general rules of benefit attribution for the scheme are stated, such as the pension increases, accrual rates and NRAs). A documentation review is also performed: the information in the CBT is compared with the software setup that WTW has for the client (this is only valid in cases where the client is not new to WTW);
2. Member Data workstage: This workstage serves to verify if the data received from the client is suitable to perform the calculations, with the highest level of quality and accuracy possible. After a general check, the data is imported into the software and more in depth checks are performed;
3. Last Time's Basis Workstage: This step consists in performing the calculations using the assumptions made in the previous valuation. These calculations are followed by verifications of the results produced, to make sure that the software is working properly and that results produced make sense;
4. New Bases workstage: The calculations are performed as they were in the previous workstage but the assumptions are changed, taking into account the information stated in the Run Request Form.

A closer look at the documentation review, Member Data and Last Time's Basis workstages will be provided later.

The software used for actuarial valuations by the LSC consists of two main tools: euVal Data and euVal Liabilities.

EuVal Data allows for the data received to be processed and corrected, if necessary. After the data is ready to be used for the calculations then an Output Run is performed to load the data into data sets that will be used in the following workstages by euVal Liabilities.

EuVal Liabilities allows for the input of assumptions (Benefit Structures, Economic and Demographic Assumptions) and performs the calculations, producing results.

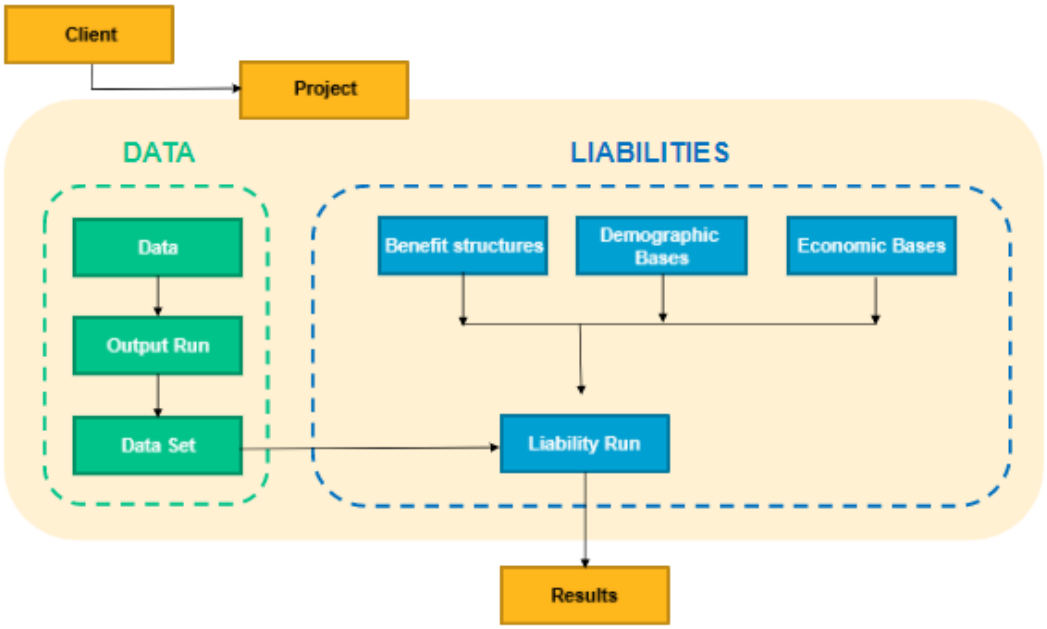

Figure 1. The different inputs in each software tool and their connections

Source: WTW Training Materials 2021c

It is clear to see how actuarial valuations can be a complex activity: besides the complex calculations and data handling that needs to be done, the setting of assumptions needs a high level of attention as it involves some uncertainty. Taking this into account, a focus on operational risk is a logic concern and will be contextualized in the next chapter.

3. Operational risk

3.1. Operational risk definition and scope

Risk has been a part of life since the beginning of times and its management is often an unconscious activity that every living being partakes in.

Operational risk is present in every activity, from a country's military to insurance companies and banks. It is an inherent part of business that is impossible to cut out and can lead to very large losses. Therefore, its management is of vital importance to companies and other entities. Operational risk can be defined as *"the risk of direct or indirect loss resulting from inadequate or failed internal processes, people and systems, or from external events"* (Basel Committee on Banking Supervision 2001). Later a link will be made between operational risk and defined benefit pension schemes in specific.

Operational risk management is not a concern that appeared recently, however it gained attention not long ago due to public incidents that led the world to question what we should be doing to prevent these events. A scandal that contributed to this awareness was the bankruptcy of the Barings Group (Reserve Bank of Australia 1995).

Barings Group was established in the eighteenth century and, over its two-hundred year history, gained a reputation as being a respectful institution that even counted England's Queen Elizabeth II as a client. Such an established company surely would be hard to bring down but all it took was a young trader: in 1995 Nick Leeson, Barings' head of derivatives in Singapore, traded away one billion dollars through speculation, leading the company to be declared insolvent. (Smith 2020)

Further research into the bank's collapse found that the losses incurred were mainly due to failures in the control mechanisms set in place. It was found, for example, that the subsidiary of Barings Group that Leeson operated in lacked separation between front and back office, which meant that Leeson could perform the trades and at the same time hide their details from the group's management. Red flags being ignored by management was also a big contributor to the disaster: funding to the Singapore subsidiary was twice the Barings Group capital right before the event, the recommendations of internal audits were set aside for later than they should have, and the extremely high profits coming from supposedly low risk trades were never questioned (Reserve Bank of Australia 1995).

From this example, it is clear to see how one person's misbehaviour, on top of the lack of robustness of a company's operational risk management, can lead to collapse.

The fall of financial institutions leads to disastrous social consequences. Usually, it means that large sums of money are lost, often the entire life savings of the institutions' clients, leaving them hopeless and without anyone to take responsibility for the losses and possible reimbursements.

The collapse of Portugal's Banco Espirito Santo shows a perfect example of the reputational impact of the downfall of institutions, with its memory still fresh in the Portuguese people's mind (Jornal I 2015). Banco Espirito Santo, like Barings Group, was a very well established and respected institution until its 2014 collapse, which caused certain clients to lose access to their savings. The entire event received extensive media attention and, besides the people directly harmed, it was clear that throughout Portugal, the trust in banks and other financial institutions was severely damaged (TVI24 2014).

The turning point for major reform in the regulations was the financial crisis that started in March 2008. It is considered to be the greatest and most impactful economic crisis since 1929's Great Depression (Amadeo 2020). To see the impact that this reform had on the world, we will look at the European case.

In 2008, the European Commission requested recommendations on the actions to take from a High-Level Group. The report produced suggested the creation of a European System of Financial Supervision (The High-Level Group on Financial Supervision in the EU 2009).

The Level 3 sectoral committees, which were committees composed of national supervisors who issued advisements on the creation and adoption of regulations, were also promoted to European Supervisory Authorities (the European Banking Authority, the European Securities and Markets Authority and the European Insurance and Occupational Pensions Authority) (European Commission 2021).

The European Supervisory Authorities are in charge of micro prudential supervision, coordinating national level supervisory authorities, while also working together with the European Systemic Risk Board, which is responsible for macroprudential supervision (Borginho 2020).

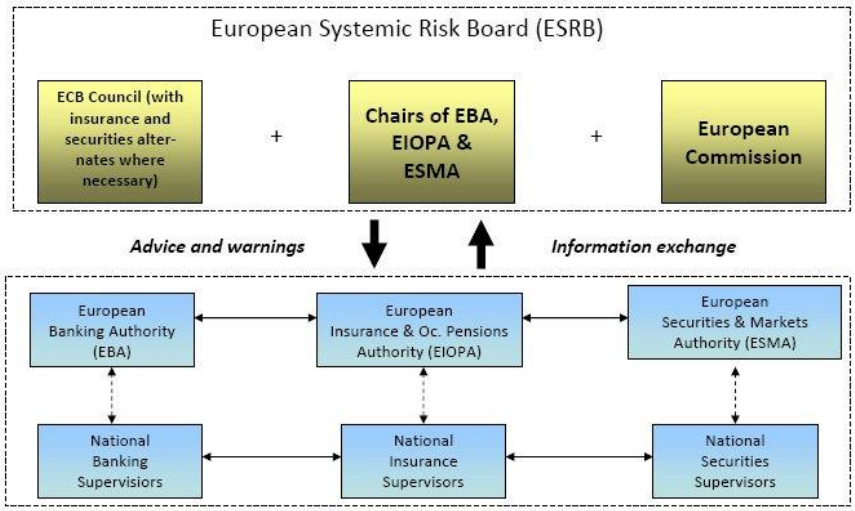

Figure 2. European System of Financial Supervision
Source: ESMA 2021

As seen in this chapter, operational risk has been taken more and more into consideration and supervisory authorities are now more aware of it. Given the relevance of operational risk, a closer look at the events that can lead to losses is required.

3.2. Loss event types

Operational risk can bring severe impact on a business, on a financial and reputational level, as previously seen. The causes of loss due to operational risk are mainly people, the systems of governance or businesses themselves and external events (Banco de Portugal 2014).

The Basel Committee has set a classification of the events where loss occurs by type. These are: internal fraud, external fraud, employment practices and workplace safety, clients, products and business practices, damage to physical assets, business disruption and system failures, execution, delivery and process management (Basel Committee on Banking Supervision 2002).

Internal fraud can be defined as a deception or illegality performed by at least one employee against their employer. It can take the form of payment fraud (a type of deception that consists of faking payments or misdirecting them) or employment of assets and information (this fraud involves the use of assets or intelligence specific to the company in ways that are not official and authorized). (Action Fraud 2021)

External fraud is a type of fraud whose guilty part is outside of the organisation being attacked. It is usually performed by customers, suppliers or competitors of the harmed company (Florida Atlantic University 2021). Customers can be guilty of frauds related to credit card or cheque usage. Suppliers can be involved in fraudulent activities through the collection of payment for

services that were not provided, providing less than the promised amount of product or even by selling a faulty, useless, product.

Losses from employment practices and workplace safety are due to the unfulfillment of health and security guidelines in place, as well as acts of discrimination. These events can lead to the employee suing the employer to obtain an indemnity. An example of this is the lawsuits due to discrimination in the workplace, which have led companies like Google, Uber or Coca-Cola to pay millions of dollars in lawsuit settlements since 2018 (Sonnemaker 2021).

The loss events that can arise in the area of clients, products and business practices are related to the neglect to meet professional commitments and agreements. A recent infamous example of such an event is the Theranos fraud (Hartmans et al 2021). Theranos was a company started by the entrepreneur Elizabeth Holmes in 2003 and, at one point, its value reached nine billion dollars. However the product that the company sold, supposedly a device that could perform extensive blood analysis using a single drop, was not yet scientifically possible.

Damage to physical assets is an operational risk loss event type that is usually associated with natural disasters or acts of vandalism. In 2011 an earthquake caused one of these types of issue: a nuclear accident in the Fukushima Daiichi nuclear reactors in Japan. One hundred thousand people were evacuated from their homes and over forty one thousand still live as evacuees from the area as of July 2020 (World Nuclear Association 2021).

Business disruption and system failures usually occur as a result of telecommunications, hardware and software issues. Power outages can cause these events as well as cyber attacks or bugs.

Loss events resulting from execution, delivery and process management arise from problems within the processes themselves: errors with data, miscommunication, or the wrong execution of tasks.

These issues can be addressed in a way that manages operational risk in an effective way, through strategies that will be mentioned in the following topic.

3.3. Operational risk management

When left unchecked, operational risk can cause the destruction of companies and organisations. Fortunately, humans have learned from past mistakes and operational risk has been taken into consideration now more than ever. Each organisation usually has guidelines or

even entire departments dedicated to internal control and quality. WTW, for example, has the Excellence Team, which will be covered extensively in later chapters.

A sound operational risk management is rigorous, continuous and, after the identification of the operational risks, should include steps of response, report and monitorization, in order to have the correct information to prevent loss events and even monetize on the risk. (Banco de Portugal 2014)

The Basel Committee gives very thorough guidelines on the steps that banks should take to ensure proper management. The organisation's governing bodies, namely the Board of Directors and Senior Management, should work together in developing and implementing a robust governance structure that follows the established and periodically reviewed operational risk management frameworks.

In addition to these roles attributed to the governance of the organisation, the Basel Committee also provides guidance on the establishment of a Risk Management Environment, consisting in three main steps: Identification and Assessment, Monitoring and Reporting followed by Control and Mitigation (Basel Committee on Banking Supervision 2011).

Risk Identification has the goal of taking data from loss events and process flow, as well as spotting the organisation's exposure to operational risk through the examination of the business procedures in place.

After the Risk Identification should come the Risk Assessment, which takes the identified risks and performs a deeper analysis on them with the aim of analysing their likelihood and severity.

Risk Monitoring can be done with the help of specific marks and indicators set in the Risk Identification and Assessment. Its performance should be thorough and frequent, embedded into the business culture, and should lessen the likelihood and need for Risk Mitigation and Control.

Risk Mitigation and Control is the implementation of measures to prevent or diminish impacts of operational risk loss events.

As previously seen, operational risk loss event types come in all different shapes and sizes. Even though the Basel Committee and Banking have been referred to, the issue of operational risk is present everywhere, spanning many different industries, services and activities. In the next section, special attention will be given to the subject of operational risk in a context of defined benefit pension schemes.

3.4. Operational risk management in defined benefit pension schemes

Pension schemes in general, and defined benefit pension schemes in particular, are exposed to several types of operational risk. There are many different variables, data and assumptions being considered. With the wrong approach and lack of care, this uncertainty can cause serious problems, but through some steps that are often simple to understand and explain this uncertainty can surely be utilized for the benefit of the pension scheme by diminishing its operational risk exposure.

The attention given to the management has been rising more than ever, largely because of the *"increasing complexity of financial products, growing reliance on automated and integrated systems, online communication and outsourcing arrangements"* (Stewart, F. 2010).

As previously mentioned, the actuarial valuations on defined benefit pension schemes that are performed at WTW rely on the company's software (namely euVal Data and euVal Liabilities), which automates several calculations, creating some distance between the valuations and the technical experts performing them.

It is worth noting that, under the previously mentioned loss event type classification, the negative events that could arise from the valuations' exposure to operational risk could fall under the category of execution, delivery and process management. The quality of the results can have an impact on how the pension scheme is viewed and can influence future investment choices by the scheme's trustees.

Clearly the automation of these processes has many benefits in terms of accuracy of the results provided and diminished human error and, with the correct risk management mechanisms, the advantages can surely outweigh the possibility of negative consequences.

According to the OECD's Pension Funds' Risk Management Framework, there are five areas that contribute to the design and implementation of control mechanisms, the core of risk management guidelines (Stewart, F. 2010):

- IT Systems: security of these systems is of the highest importance to operational risk management, as today's pension scheme management and valuation services rely heavily on technology. This dependence became even more evident after the Covid-19 Pandemic, which forced the implementation of remote work for many people all around the world. Calculations are performed using appropriate software, cloud services are used to share important files (like data and analysis results) between team members, emails containing possibly classified information are shared between work colleagues

or clients and service providers. To protect all this information, the data should be properly backed up and protected, system recovery should be enabled and appropriate authentication solutions must be in place;

- Monitoring Systems: as previously seen in the short analysis of the collapse of Barings Bank, business procedures must be monitored and by as many mechanisms and people as possible. Everything should be double checked by different people since trusting high levels of responsibility on a single person without any monitorization is highly risky;
- Internal Audit: organisations should look within and question whether they are meeting all the regulations and requirements, with a high level of detail. Looking into every corner, every department and available information is key;
- Performance Measurement and Compensation Mechanisms: the workers involved in the operations of the company should have their skills verified often to ensure they are skilled enough to take on their assigned responsibilities. Proper compensation is also of the highest importance as it provides incentive for good behaviour and adherence to procedures;
- External Controls: As companies should not have to be their own regulators, external input is vital through the evaluations by supervisory authorities or external audits.

In this chapter, an investigation of operational risk and its connections to defined benefit pension schemes was performed. Next chapter will contain an analysis on the LSC's mechanisms to ensure the maximum quality of their services.

4. LSC's steps to manage operational risk

Operational risk management is of extreme importance to WTW, and to the LSC in particular. The complexity of the actuarial valuations means that it is very important to work towards preventing and managing mistakes that could impact the meeting of deadlines and the delivered results.

The framework that allows for an efficient risk management at WTW consists of internal control processes to ensure excellence (such as the Work Review Policy and the Excellence Review), as well as stages included in the actuarial valuation itself that function as a way of checking the quality of the data received, assumptions and results, throughout the procedure (such as documentation reviews, data checks, roll forward checks, standalone checks and analysis of surplus).

4.1. Excellence team and Processes team

Excellence is one of WTW's main values and the concept is meant to represent the company's aim of delivering the best possible results, focusing on quality instead of just quantity. This means producing work that is technically sound and meets the client's needs. The benefits of this focus on quality are mainly an improved consistency and client experience, as well as a reduction in effort and in risk.

The Excellence team is in charge of upholding this value at the LSC and ensuring that all quality control systems are being applied.

In order to maintain Excellence, a key system of examination is in force: the Work Review Policy. In the policy it is stated that all work must pass through a well-documented review before reaching the delivery stage. There are usually three stages in this process, each performed by different people:

- Preparation stage: a qualified associate (the preparer) produces the actual work with the highest rigour possible, even though it will be reviewed after;
- Checking stage: an experienced associate (the checker) performs an analysis of the worked produced, looks into any possible problems that might have appeared and supports the preparer of the work on any issues that might emerge;
- Reviewing stage: a final look at the project performed by an experienced member of the team (the reviewer), working with the checker and the preparer to ensure that there are no mistakes or inaccuracies in the final product.

Besides the people assigned to the three stages of each task, each project has a Project Manager who is responsible for managing the allocation of each task, the deadlines and the general state of the ongoing project.

To ensure that this policy and all other quality control procedures are being applied by the Excellence team, there is an Excellence Review taking place every two years by a WTW team that reports to the company's Executive Committee and to the Risk Committee of the Board (WTW Internal Documents 2021a). Besides analysing compliance with the company's standards, these reviews also serve to solve any possible issues being faced and to educate all associates on the importance of Excellence.

The LSC has implemented a Processes team that consists of actuarial analysts with experience in UK Valuations who develop, test and improve the software while also working on automating some processes, mostly through the implementation of macros that make it easier to fill certain Excel templates.

4.2. Operations quality management: three dimensions of quality

WTW's Quality Management System has the main goal of understanding and continuously improving quality standards of the services provided by the company. For this, the Three Dimensions of Quality (3DQ) approach is used.

The 3DQ approach is very useful to ensure that the team that produces the work is the actual team ensuring its quality, bringing more awareness to this subject (WTW Internal Documents 2021b). It allows for proper and quantifiable measurement and visibility of quality issues, which leads to an improvement in the quality of output and a consequent reduction in efforts because of a smaller need for redoing work to correct mistakes.

The Three Dimensions of Quality are:

- Dimension 1 (Input Quality): addresses the standard of the inputs received by the person in charge of the work and can lead to major failure throughout the following processes. Since certain issues can be recurrent, the registration of each problem and solution into a file that can be accessed in the future is highly encouraged;
- Dimension 2 (Throughout Quality): it is related to the standard of work actually being conducted and can be the dimension that has the most understanding from the people who conduct the tasks;
- Dimension 3 (Output Quality): it is the most important factor in determining the quality of the developed work as it is related to the standard of the final work delivered to the

client. It is also the one that can lead to the worst consequences because, besides a final result of poor quality leading to higher levels of correction work, it also impacts the customer's experience and trust in the company.

The concept of materiality relates to the assessment of whether a deviation between the result obtained and the expected has a significant impact on the final results of the project. If materiality is not well defined it can lead to confusion because the choice between identifying a difference as significative or not can vary widely, depending on the person who is deciding. Materiality is, therefore, a topic to be considered and not only in the performance of actuarial valuations but in many different types of activities.

The actuarial valuations process has different stages that can be seen as different levels of checks. We will look into each one in more detail and present some common issues that can occur, or problems that can be identified in that stage, along with how they can be managed. These examples are based on my personal experience working as an actuarial analyst and on interviews conducted with more experienced members of the UK Valuations team.

4.3. Documentation review

Each time there is a request for a valuation, the CO team must send a document which is the CBT. The CBT contains information on the pension scheme such as whether the plan is Final Salary or CARE, the NRAs and the assumptions to be used for the application of increases. This information is then compared with what the LSC has embedded into the setup for the calculations.

For example, if a plan changes from being a Final Salary to CARE, changes must be arranged so that the system passes from only requiring information on one salary to processing several salaries.

However, accommodating change is not the documentation review's only purpose. It can also be useful to identify some information that might not be very clear, or even wrong information. As an example, we will consider the following hypothetical scenario: a pension scheme's CBT states that the approach to be used is CARE. However, on the software, the approach being used is Final Salary. Since this change can mean a big impact on the calculations, it is worth taking a closer look, maybe by analysing the previous available CBT (the one that had previously passed a documentation review against the inputs on the software). It could be the case that, in the previous valuation, the same thing happened: the information in the CBT did not match the software inputs, and maybe at the time the LSC was warned that the CBT was wrong (which

means that the same could be happening in this valuation). The method to be used should be clarified with the CO team in this case and an error could have been prevented.

After all the software is setup correctly with the pension scheme's provided information, there is still one major aspect to consider before proceeding with the calculations: ensuring data quality. For this, the data checks Workstage is vital, it is a key part of the entire process.

4.4. Data checks

When raw data from the pension scheme administrator is received, so that the valuation can be initiated, there is the possibility of some incorrections, for instance, some fields or members that can be missing. If calculations are performed in these conditions, this could lead to very misleading results. Something to be considered is also data privacy: sometimes the pension scheme's administrators can send personal data that should not be shared with the LSC or passed to the software, like the members' names or surnames. To prevent this, the LSC conducts verifications and corrections on the data before any calculations are done.

The first step is to map the received fields to the data fields in the software. In the case of first valuations there are no fields already created, so they must be mapped to new ones that will be named according to the available naming conventions and standards. If a previous valuation's fields are available, mapping the received fields to existing ones allows for a comparison between the data received and the data already processed in the last valuation. For example, if in this year's raw data there is a column named "Pre 97 Excess Pension" and in the previous valuation's raw data there is a column named "Pre97 XS Pension", which at the time was mapped into a field on the eVal Data software named "PRE97XSTVD", we can conclude that both represent the same type of pension, with slightly different names. However, if we also map "Pre 97 Excess Pension" to "PRE97XSTVD", the amounts will be considered as being of the same type, and therefore comparable, which is an efficient way of immediately realizing possible flaws in the data.

After this mapping process, we proceed to individual comparisons of the pension amounts at LVD and TVD for several members, chosen to be as representative of the whole population as possible. Here we can get a first glimpse of some problems: maybe a member had a change in date of birth or an unexpected increase in a pension amount in the intervaluation period.

The next step is importing the data that has gone through these more general checks into the eVal Data software. Thanks to the mapping previously done, all pension amounts should fall into

the correct data fields embedded into the software. Then, an extract will be produced to perform more thorough checks.

These detailed checks are performed separately for each different status and, within each status, they are divided into different categories. This way, checks can be made to see if there is any unusual number of blanks in the provided data, compare the movement of members between states, or observe differences in each pension amount from LVD to TVD and see if they match what was to be expected given the assumptions.

For example, within retirees we would expect a very large increase in GMP and a decrease in Pre 97 Excess pension, for retirees who were below GPA at LVD and above GPA at TVD. This is due to GMP savings for members of this status who went from being under GPA to over GPA in the intervaluation period. GMP savings is an approach for calculating the correct GMP liability, necessary for members who retire before GPA: the GMP comes into payment at GPA, with its specific increases, while the portion of liability that came into payment at retirement, with excess increases, is subtracted. If an accentuated increase in GMP, accompanied by a decrease in Pre 97 Excess pension, happened for retirees who did not go from being under GPA to over GPA, it would be something to point out. In the end, if there are issues that could significantly impact the calculations, questions are raised to the data provider and, once they are answered, the action to be taken is either to accept the issue as normal or to make corrections in the imported data.

After the data checks, the valuation proceeds and the calculations are executed. However, the quality control of the process does not end here: another stage of verifications is implemented to, once again, verify the accuracy of the results.

4.5. Standalone and roll forward checks

In the Last Time's Basis Workstage, the assumptions used in the last valuation are used to perform calculations on the software, with the newly received data. The results of these calculations are then checked in two main ways: through standalone checks and roll forward checks. Standalone checks serve to see if the software is running properly by performing the same calculations but in a different way. The roll forward checks take the results from the last valuation, plus the assumptions that were made at the time for the future and calculates an expected value for the liability. This expected value is then compared with the actual value that was obtained with the software and the new data.

An important component of actuarial valuations is the Analysis of Surplus (AoS). A pension scheme's funding level is obtained by dividing its assets by its liabilities. The AoS's goal is an examination of the pension scheme's funding level, together with a comparison against the last valuation's funding level. Therefore, the AoS provides an overview of the status of the scheme and can be a decision factor for pension schemes' administrators when making investment decisions. Since it is such a useful indicator, an unexpected change in the funding level in the intervaluation period can indicate that there were problems in the valuation process. However, an AoS was not included in the following chapter's simulations for the sake of a better focus on other verification mechanisms.

The LSC has several risk management processes embedded in its structure and processes, as seen in this chapter. In the following chapter these mechanisms will be demonstrated through the simulation of error scenarios.

5. Error simulation

In order to best evaluate the impacts of some possible errors (that the operational risk management processes are designed to detect) and how the LSC mechanisms above mentioned can work towards catching mistakes as soon as possible, I have simulated some common errors or mistakes. I will show here the errors and their identification through the actual processes embedded in the valuation stages. However they can also be caught through the Work Review Policy (one of the reviewers can simply spot the mistake and correct it). I also want to note that even though I will show the impacts of these mistakes in the final results, this is simply to show what are the adverse effects that the quality management at the LSC is preventing as these errors are usually caught very early on and don't end up impacting the final results.

These mistakes were simulated using a sample client, including sample data and sample pension scheme assumptions. The mistakes I simulated are based on real cases and are examples I collected through interviewing experienced members of the LSC's UK Valuations team and from my personal experience working in the valuations.

The sample pension scheme has 1208 members divided in the following way by their status:

- 55 dependants (out of which 53 are spouses and 2 are children);
- 400 retirees;
- 519 deferreds;
- 234 actives.

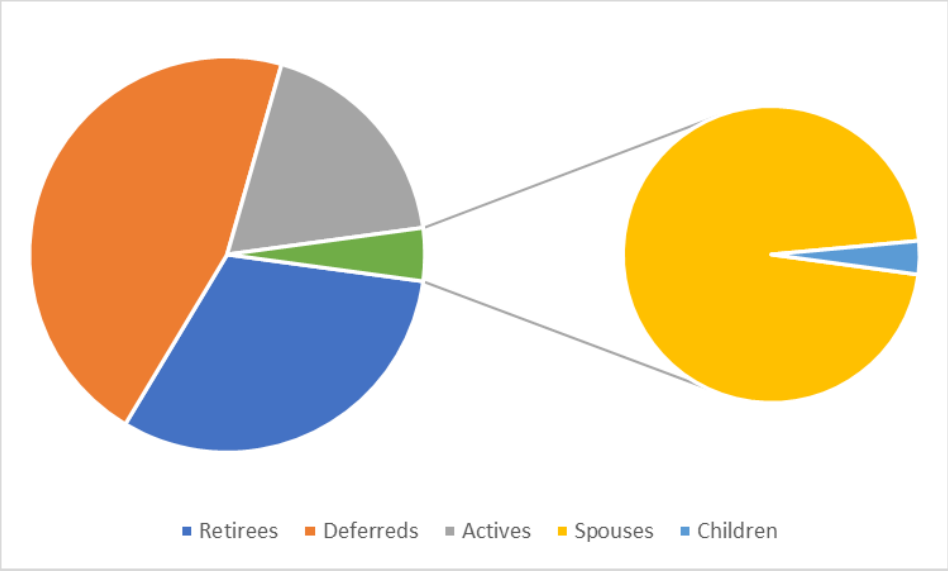

Figure 3. Breakdown of the membership by status

The NRA and the unreduced payment age of this scheme are both 65. The benefits are based on Final Salary. The revaluation of GMP in service is calculated according to the Fixed Rate methodology and, in deferment, it is determined using the Section 148 method. The increases of excess pension in deferment are in line with CPI while the increases applied during payment are based on RPI.

5.1. Setup errors

Errors of the setup usually consist of errors in assumptions that were fed into the software. Since many pension schemes being analysed have already been subject to previous analysis by the LSC, it is possible to overlook changes that the scheme requires from valuation to valuation, without the proper control mechanisms. The growing automation process is also a contributing factor to detachment from the preparer of the work and the setup which, without a proper review, could lead to some mistakes going unnoticed. However, the documentation review forces the actuarial analysts to confront the software and how the calculations are being made. To demonstrate these mechanisms in action, I picked five errors to simulate in the euVal Liabilities software. The choice of the specific cases was based on my own experience, through working in actuarial valuations during my curricular internship and errors that I saw being identified in the process.

The errors simulated in this section will be:

- A switch between CPI and RPI;
- An age switch;
- Increase date switch;
- No mortality improvements added;
- Wrong salary escalation assumption.

5.1.1. Switch between CPI and RPI.

In this example I will consider the following situation: the CBT states that certain increases should be based on CPI and others on RPI. However, in the setup in euVal Liabilities from LVD, all the supposed CPI increases appear as RPI and RPI appear as CPI, contradicting the CBT. However, without the LSC's knowledge, the CBT from TVD is incorrect as there was a mistake and the person writing the information switched CPI with RPI. Since the CBT contains the new information, without performing the documentation review, the difference in setup would not be questioned and we would use the wrong information from the CBT. This confusion can also be the cause for the other setup errors that will be presented.

For this example I switched all the CPI increases to RPI and changed RPI to CPI in the benefit structure of all different statuses.

This change should affect all statuses as all of them are subject to either in payment or in deferment increases.

5.1.2. Age switch

This error consists of a switch in the NRA and the unreduced benefit payment age from 65 to 60.

The expected impact on results is an increase in liability for actives and deferreds, as five extra years of pension payments to members are being considered. Changes in the liability for retirees and dependants are not to be expected with this error as pensions are already in payment for members of these statuses.

5.1.3. Increase date switch

Pension amounts are often subject to increases, as previously mentioned, mainly to keep up with inflation. For this example, the date at which in payment increases are applied was switched from 31 March to 31 October. This change will surely cause an impact because it would impact the timing adjustment by seven months.

5.1.4. No mortality improvements added

Mortality tables are an important tool for performing actuarial valuations, since they are used to set assumptions on the mortality of the pension scheme's members. Very often mortality tables are static, which is why improvements are added, to allow for more accurate predictions. In the UK, the Continuous Mortality Investigation (CMI) issues both mortality and sickness tables which provide improvements that can be added to mortality tables in place (IFoA 2021).

For this error simulation, the mortality improvements added to the mortality tables in place for the scheme were removed. This alteration is expected to have an impact on the liabilities of all four statuses.

5.1.5. Wrong salary escalation assumption

In defined benefit pension schemes, whether a CARE or Final Salary approach is being used to calculate the pension that the member is entitled to, setting assumptions for the evolution of member's salaries is of extreme importance.

By changing the salary escalation rate from 4.2% to 8% in this mistake simulation, the result will surely be an overestimation of the scheme's liability. However, this will only affect the active status. Since the final salaries of deferred members are already known, because they left the pension scheme by leaving their employment, and the retirees and dependants are already receiving pension, the liability for these statuses will not be affected.

5.1.6. Final considerations

After the error scenarios were defined, calculations were performed to see the impact they could have on the results.

The next table shows the differences between the liabilities that resulted from the correct setup and the liabilities that resulted from the simulated error scenarios, both by status and in total. The cells are highlighted in the following colours, according to their relative differences:

- Red cells (corresponds to relative differences larger than 15%);
- Orange cells (corresponds to relative differences smaller than 15% and larger than 7%);
- Yellow cells (corresponds to relative differences smaller than 7% and larger than 3%);
- Green cells (corresponds to relative differences smaller than 3%).

	Index Switch	Age Switch	Increase Date Switch	No Mortality Improvements	Salary escalation changed
Dependants liability	5,21%	0,00%	1,22%	8,80%	0,00%
Retirees liability	4,75%	0,00%	1,26%	9,09%	0,00%
Deferreds liability	6,48%	-26,27%	0,00%	10,71%	0,00%
Actives liability	3,27%	-10,74%	0,00%	10,56%	-37,79%
Total Liability	4,44%	-11,86%	0,32%	10,23%	-19,00%

Table 1. Difference between the correct liabilities and the results of the setup errors

The difference between the correct liability and the liability from a specific error is calculated in the following way:

$$\frac{Correct\ Liability - \ Liability\ from\ the\ error\ scenario}{Correct\ Liability} \times 100\% \qquad (2)$$

Below is the graphic representation of the absolute value of the total liability of each simulated error compared to the correct liability.

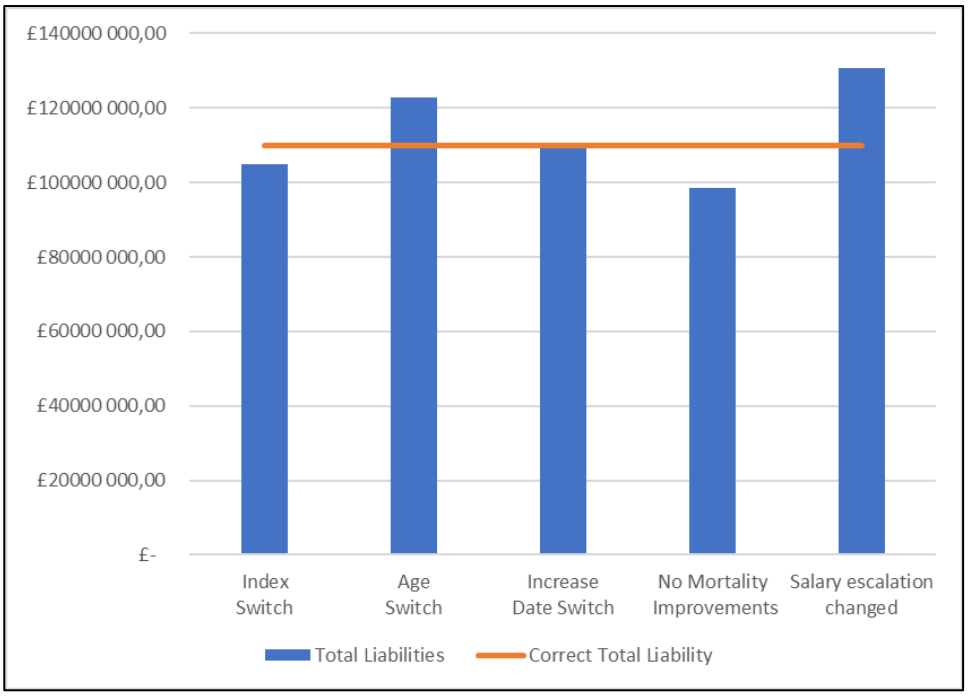

Figure 4. Total liabilities in each error vs. total liability with the correct setup

As can be seen in Table 1, the error with the least impact on the total liability was the switch in the increase date (if we exclude the cases where a 0% change was expected, as the error should not impact the liability of a particular state). This is also the error with the least impact on the liability of each status, showing that a different increase is not necessarily one of the most vital assumptions to be made in actuarial valuations (even though it has its importance).

The index switch did not result in a change as significant as the ones resulting from some of the other errors. This could be expected because the difference between CPI and RPI is very often small. Still, it resulted in an underestimation of the liability for all statuses.

In the error scenario where no mortality improvements were added, the liability was underestimated for all statuses, when compared to the scenario where no errors were added. This can be explained by the following fact: it is always assumed that average life expectancies increase as time goes by. Removing the improvements means that this assumption of the increase in average life expectancies is not being taken into consideration. Since the continuous aging of the population is not being considered in the proper way, less future pension payments will be considered in the calculations and the liability will be underestimated.

The switch of the NRA and unreduced benefit payment age from 65 to 60 caused an overestimation of the liabilities for both actives and deferreds, as expected: this switch adds five more years of pension payment. Since the actives are likely to have, in general, more years until

retirement than the deferreds, any difference in the age at which the members are assumed to start receiving pension will have a greater impact on deferreds.

The simulated error that impacted the total liability the most was clearly the wrong salary escalation rate, even though it only affected one status: actives. As previously seen, the calculation of the pensions is usually based on a percentage of the members' final salary, or of a specific number of last salaries. Therefore, increasing the salary escalation rate from 4.2% to 8% should lead to a significant overestimation of the pension amounts, and an overestimation of the liability for actives. This error analysis highlights how a simple error when writing a single percentage can mean a very large difference in the final results.

As seen in 5.1.1., these setup errors can be easily identified in the documentation review. However, they can also be caught through the data checks, standalone checks, roll-forward checks, or even through the work review policy. In the next section, it will be shown how data checks, together with roll forward checks, can guarantee accurate results.

5.2. Input errors

As we previously addressed, the data workstage is vital in making sure that the data received is of the highest quality possible to perform the calculations. Mistakes in the data can lead to inaccuracies in the results produced, which influence the investment decisions for the pension scheme.

Errors can lead to an estimated liability amount that is lower than the actual estimation, if the data were correct, meaning that the pension scheme administrators would think that the scheme is better funded than it actually is. The opposite would happen if the estimated liability amount was higher than the actual estimation with correct input. While overestimating a liability is not as dangerous as overestimating it, it can still be damaging.

For this section three errors were simulated, for the deferred status:

1. Switching DOL with TVD;
2. Missing amount;
3. Pre 97 Excess amounts switched with Post 97 Excess amounts.

The choice of the deferred among all of the membership statuses was because this is a state with much more uncertainty associated when compared to retirees or dependants: deferreds and actives have more years until they receive any pension, when compared to retirees and dependants, and the date the pension payment begins is not yet known (even though the NRAs

are defined, there is always the possibility of early or late retirement). In terms of the choice between the active status and deferreds, the latter was chosen because it is more representative of the actual reality of actuarial valuations: defined benefit pension schemes are becoming less frequent as time goes by, so many schemes don't have active members.

This error simulation was achieved by changing the raw data provided in csv format and then importing the data into euVal Data. To better understand how input errors can be caught, this simulation was performed in the sample client's 2020 valuation job (considered to be the TVD job, while the 2019 valuation job is considered to be LVD), to be able to see how some verifications using LVD's data and results work. Since there have been exits between both valuations, the membership whose status is deferred has been reduced to 504.

5.2.1. DOL switched with TVD

In this mistake simulation all of the member's DOLs were switched with TVD (31st of December 2020). This means, in practice, that all amounts that should be situated at DOL will now be considered as situated at TVD; since DOL is always at or before TVD, then the implication is that all amounts will receive less revaluation than they were supposed to.

The earlier stage of the process where this can get caught is in the data workstage: more particularly by analysing the Data Checking template (DCT), the template used for the data checks. There is one section in the document that deals with checks for members who remained in the deferred status since LVD, as the best way to determine actual errors in data is by analysing members who have data available from the previous valuation.

Within this section of the DCT, there is a subsection called "Check for changes in 'sx' deferreds data since LVD in data items where changes should not occur" ('sx' deferreds being the members who remained in the deferred status in the intervaluation period) where the first sign of an error can be seen:

Data items	Number of changes		Total deferred pension at DOL for affected members	
	Number	% of total sx	£k	% of total deferred pension for sx deferreds
DOL	504	100.0%	1,089.0	48.1%
DOB	0	0.0%		

Figure 5. Check of the DOL and DOB (Date of Birth) for members who remained in deferred status in the intervaluation period
Source: WTW Templates

As can be seen in Figure 5, all 504 members have a different DOL when comparing to last valuation, which makes no sense in the deferred status: once a member leaves service, that DOL is fixed and does not change between valuations in most cases (the exception is when someone re-enters the pension scheme in the intervaluation period, which is unlikely but not impossible).

Section 8 of the DCT serves to check minimum and maximum dates for deferreds. This is a very useful tool for identifying what can be wrong with the dates.

Dates	Description	Minimum	Maximum
DOB	Date of birth	24/11/1947	02/06/1986
DOL	DOL	31/12/2020	31/12/2020

Figure 6. Check on the maximum and minimum dates
Source: WTW Templates

Unlike the observed for the dates of birth, where the minimum and maximum found seem reasonable, Figure 6 shows that both the minimum and maximum dates registered in the DOL field are equal to the valuation date, which makes no sense in this case. It would be very strange for all of the recorded dates of leaving to be equal.

While the error can be easily identified in the data workstage, it is also easily identifiable in the Last Time's Basis Workstage, particularly in the roll forward checks.

Below we can see the final results of the check for this run.

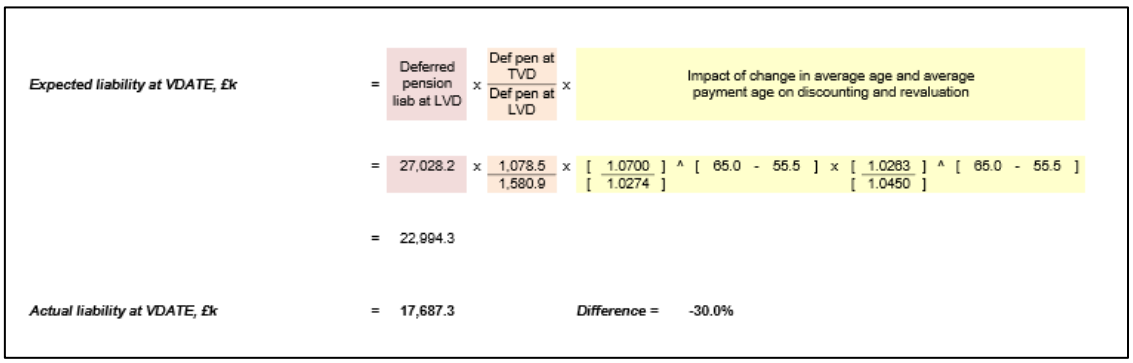

Figure 7. Expected and actual liabilities for the error where DOL was switched with TVD
Source: WTW Templates

The roll forward checks aim to take the deferred pension liability obtained at LVD (in the first coloured box from the above picture) and multiplying it first by a factor meant to reflect the changes in the size of the group between LVD and TVD (this is the second coloured box from the above picture, the pension amounts at TVD divided by the pension amounts at LVD) and second

by a factor that takes into account the changes in average age of the members and average pension payment age between LVD and TVD (this is represented in the third coloured box). The result of these two multiplications is considered to be the expected liability at TVD, which will then be compared with the actual liability at TVD returned by euVal Liabilities.

The expected liability at this valuation date, calculated by the checking template, is different from the actual liability at this valuation date, given by the calculations of the software. The difference is about 30%, which means that the calculations performed are worth checking.

5.2.2. Missing amounts

The error that was simulated here was the absence of the Pre 97 Excess. Missing data fields can happen due to several reasons: sometimes it is an error by the pension administrator, but it can also happen that one, or several, fields are sent in a separate file from the rest of the raw data and the LSC doesn't realise that it should be merged into euVal Data. One thing that can also cause this is an accidental erasure of the field from the file: occasionally the LSC receives data fields that cannot be stored or imported due to them containing personal information that is not necessary for the calculations (for example surnames or social security numbers), so they must be deleted and while doing that other fields can be deleted accidentally.

This error can have a major impact on the calculations: if it is a missing amount that serves as a deduction on the pension, then the final liability will be inflated; if it is a whole pension amount, then the final liability will be underestimated. However, the data workstage works very efficiently in identifying this problem. Given that the amounts provided are at DOL, if we look at the pension amounts for members who were in the deferred status by both LVD and TVD, we would expect all of them to be the same. For this reason, it is expected that the mistake will be identified on the section of the DCT that checks amounts for members who remained in the deferred status since LVD:

Deferred pension amounts	Amount in LVDATE data	Actual amount in VDATE data	Difference		Difference as a % of total deferred pension at DOL in VDATE data
	£k	£k	£k	%	%
TOTPENDOL	1,089.0	1,089.0	0.0	0.0%	0.0%
PST88GMPDOL	71.0	71.0	0.0	0.0%	0.0%
PRE97XSDOL	157.7	0.0	(157.7)	(100.0%)	(7.5%)

Figure 8. Check of the DOL and DOB (Date of Birth) for members who remained in deferred status in the intervaluation period
Source: WTW Templates

As can be seen above, while the total pension and Post 88 GMP amounts remain the same, the Pre 97 Excess from members who remained in the status are zero, representing a 7.5% difference in the total deferred pension received in the data. This error would not pass this workstage after being identified here.

If the data workstage did not exist, the error could still be caught in the Last Time's Basis Workstage, particularly in the roll forward check:

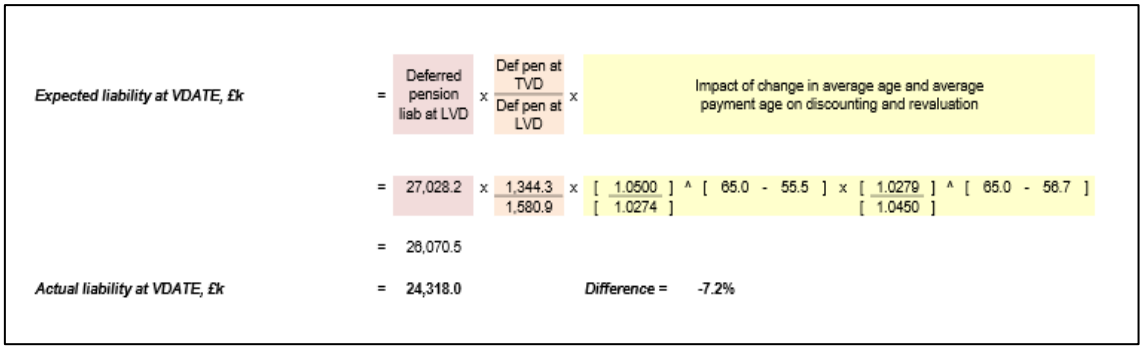

Figure 9. Expected and actual liabilities for the error where the Pre 97 Excess is missing
Source: WTW Templates

The actual and expected liabilities in this case differ by 7.2%. The difference in this case is smaller than in the previous one, however, it might still lead to a verification of the results.

5.2.3. Switched excess

Pensions are split in tranches, usually because each different tranche or subsection of pension is subject to a different treatment in terms of revaluation. In respect to excess pension there is usually a split between pension accrued before and after 1997. Pre 97 Excess is usually revalued using an inflation index subject to a cap of 5%, as well as the excess accumulated from 1997 to 2009, and the Post 2009 Pension amount (included in the Post 97 Pension data field in the sample client) is revalued using an inflation index subject to a cap of 2.5%.

With this error simulation the goal was to see the impact that switching the excess amounts can have on the liability (once more). This switch can happen during the mapping process: it is possible that the amount in the raw data is mapped to the wrong data field in euVal Data. However, just as in the previous simulated mistake, the mistake should be caught early on, on the section of the DCT that checks amounts for members who remained in the deferred status since LVD:

Deferred pension amounts	Amount in LVDATE data	Actual amount in VDATE data	Difference		Difference as a % of total deferred pension at DOL in VDATE data
	£k	£k	£k	%	%
TOTPENDOL	1,089.0	1,089.0	0.0	0.0%	0.0%
PRE97XSDOL	157.7	860.3	702.6	81.7%	31.0%
PST97PENDOL	860.3	157.7	(702.6)	(445.5%)	(31.0%)

Figure 10. Check of the Total Pension at DOL, Pre 97 Excess and Post 97 Pension at DOL for members who remained in deferred status in the intervaluation period
Source: WTW Templates

As seen above, the check makes it easy to identify that there is a problem and what it is, in specific: the Pre 97 Excess and Post 97 pension amounts were clearly switched between LVD and TVD, which meant a 31% change in the total deferred pension received in the data. The error could be caught in this workstage.

The error could also be caught in the Last Time's Basis Workstage, in the roll forward checks:

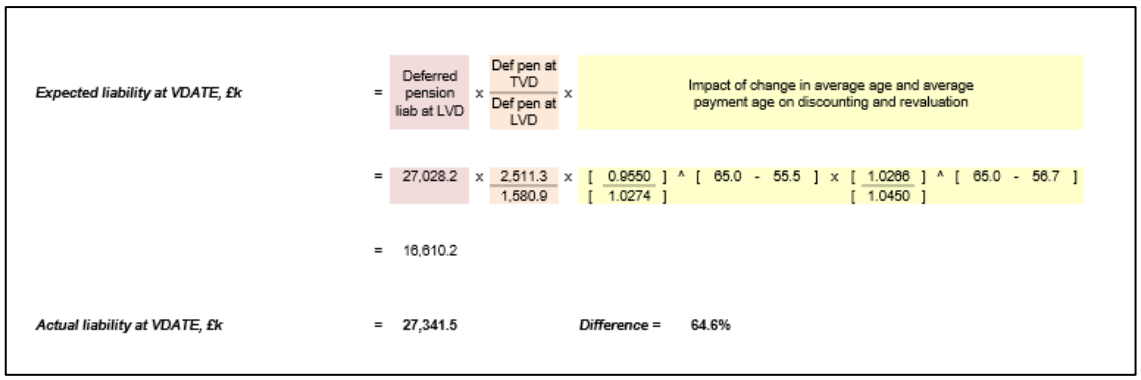

Figure 11. Expected and actual liabilities for the error where the Pre 97 Excess and Post 97 Pension are switched
Source: WTW Templates

With the switch in excess amounts, the difference between the actual and expected liability was 64.6%. It would certainly raise some questions, unless this scheme has specifications that could explain it.

5.2.4. Final considerations

The liabilities for the deferred status can be seen in Table 2 below, as well as the difference between each of the results obtained and the results produced using the correct input. The differences in this table were calculated using formula (2).

	Deferreds Liability	Difference
Correct Input	£ 27 341 537,00	0%
DOL switched with TVD	£ 17 687 309,00	35%
Missing Amount	£ 24 317 986,00	11%
Switched XSs	£ 38 441 993,00	-41%

Table 2. Difference between the correct liabilities and the results of the input errors

If the errors are organized by the respective differences in module, shown in the table above, in an ascending order, the result would be: “Missing Amount”, “DOL switched with TVD” and “Switched XSs”. By organizing the errors based on the differences between the expected and actual liabilities (the differences calculated in the roll forward checks), the same result would be reached.

The following graphic serves as a visual representation of the previous table, showing the difference between the liability resulting from each scenario and the liability calculated from the correct input:

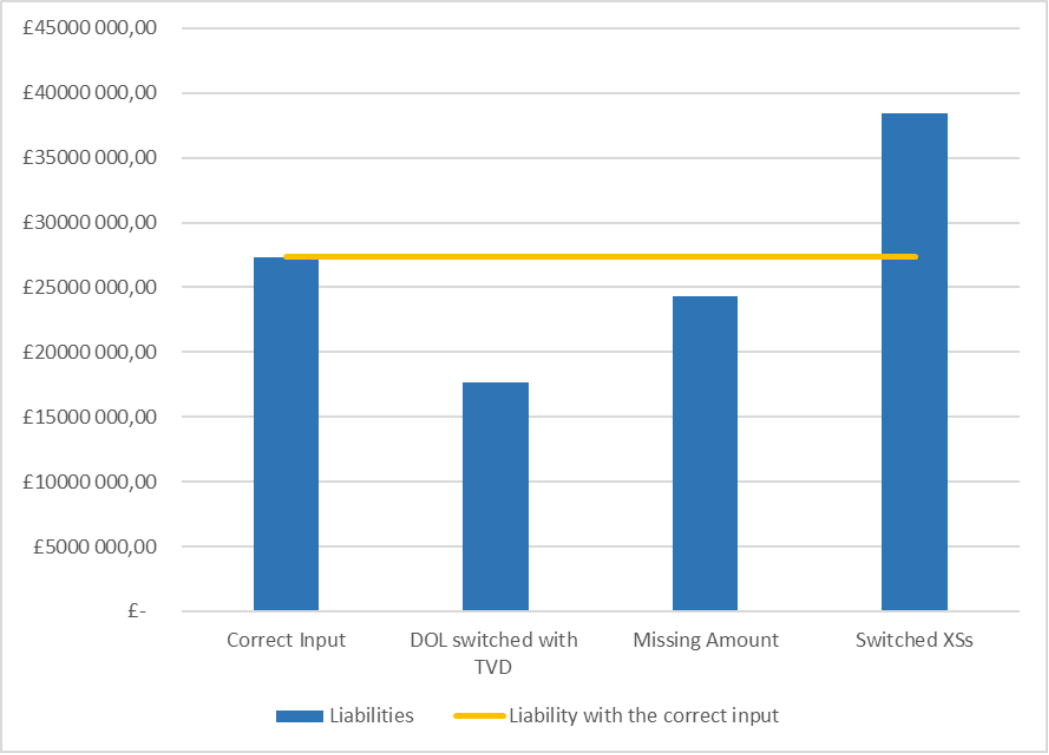

Figure 12. Liabilities obtained in each scenario vs. liability obtained with the right input

The differences align with the expected: the scenario where DOL was switched with TVD resulted in a smaller liability amount than expected and the same for the missing amount scenario.

The switched excess scenario is the one with the largest difference in module from the correct liability. This was to be expected, as the wrong cap being applied to very different amounts can be significant. In this case, the larger excess amount of the two was subject to a larger increase than it was supposed to and the other way around for the smaller excess amount, explaining the difference being positive.

6. Conclusion

Operational risk can be a big threat to organisations especially when combined with lack of regulations and a weak internal risk management system. However, if organisations, teams and the workers themselves take accountability for their own exposure to operational risk, the impact of its existence can be largely reduced. Through the extensive research on the topics of pension funds and operational risk, as well as the mistake simulation performed on the last chapter, I could understand the link between operational risk and defined benefit pension schemes. I was also able to see operational risk management through the perspective of an actuarial analyst: I could look at its impact in action, and realize how not checking the work being performed can lead to inaccuracy.

Before taking on this theme and performing the simulations (with a focus on what could happen without the various checks and reviews), I did not realize how much of an impact the loss events due to operational risk could have. For example, the simulated error where a switch between Post 97 excess and Pre 97 excess occurred: being one of the cases with the highest impact (a 41% difference from the correct liability), going unnoticed would result in an overestimation of the pension scheme's liability for deferreds by around eleven million pounds. On the other hand, the simulated error where DOL and TVD were switched led to an underestimation of the deferreds' liability by almost ten million pounds. This could lead to different types of pension fund management decisions that might not be the most appropriate. The impact could range from the least severe case, but still very damaging, (in the overestimation scenario), of simply missing out on some investment opportunities due to perceived lack of funds, to the more serious case (in the underestimation scenario) which could lead to decisions that would, unknowingly, damage the fund's ability to meet its liabilities. After seeing the possible impacts of the errors, however, it was even easier to trust the process of actuarial valuations than before: I became aware of how the whole system is designed to prevent accidents and how they could easily be caught.

There is one aspect of the whole error verification system in the UK Valuations team I think is essential, but that I was not able to demonstrate in the mistake simulation: the Work Review Policy. The fact that all results are reviewed by experienced associates, who also support the preparer of the work with any questions that might appear, is very important. The Work Review Policy surely contributed to better quality of work on my part. A company culture focused on transparency and collaboration is crucial and shouldn't be overlooked. I believe there are several other projects that could be developed in the context of my theme (which was more of an

exploration of how the mechanisms worked). A topic to consider could be the development of new and even more efficient operational risk management processes in the context of actuarial valuations, or even the automation of some processes.

Overall, my experience as an actuarial analyst showed me how actuarial valuations are a complex subject, which should be handled with the awareness of how mistakes and lack of control can affect what is, above all, the goal of pension funds: providing income for people in their later or most vulnerable stages of life. Working in actuarial valuations at WTW was truly a gratifying experience where I got to learn a lot about the actuarial profession, through my work and with the supervision of skilled actuarial analysts.

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